

From: Riverine Craft Project Officer, Marine Corps Systems Command

To: Operational Units

Subject: **Family of Small Craft Cold Weather Lessons Learned**

1. Small Craft Company (SCC), Headquarters Battalion, 2D Marine Division, deployed in February 1999 and participated in Battle Griffin-99 (BG-99). This deployment was to Norway with a contingent of Riverine Assault Craft (RAC) and Rigid Raiding Craft (RRC).

2. The Marine Corps Systems Command (MARCORSYSCOM) conducted a Developmental Test / Operational Test (DT / OT) of the Small Craft Propulsion System (SCPS) mounted on the Combat Rubber Raiding Craft (CRRC). These tests were conducted at Seward, AK, during January and February 2000.

3. Extreme Cold Weather conditions are the common thread of these two situations that tested the craft, propulsion units, maintenance conditions, facilities, and cold weather equipment supporting U.S. Marine Corps small craft. These experiences will be discussed by craft type—RRC, CRRC, RAC, and their equipment.

4. **Rigid Raiding Craft (RRC)**

A. **Topic:** Cold weather preparation of the RRC

Discussion: The RRCs operated well in the cold weather with a few minor adjustments. Special precautions regarding the use of TC-W3 were made. It was anticipated that the Variable Ratio Oil (VRO²) systems 2-cycle motor oil (TC-W3) might be too thick to provide ample amounts of oil for the engines to operate properly. Two options are available:

1) Disconnect the VRO² system using the following procedures. Install protective cap, OMC P/N 315391, over the oil inlet fitting to protect the VRO² pump. Secure with clamp OMC P/N 322654. Disconnect the VRO² wiring harness. Seal engine harness Amphenol connector with cover, P/N 335655. Directly add the TC-W3 2-cycle motor oil into the fuel tank to achieve a 50:1 fuel oil ratio. These procedures are taken from the OMC Service Manual.

2) Mix the TC-W3 2-cycle motor oil into the fuel tank and also use the VRO² system. Depending on the fuel/oil used in the fuel tank, the engine will be running a rich mixture. This will result in degradation of top end speed and could possibly cause spark plug fouling.

Recommendation: Use a fuel/oil ratio of no less than 50:1. Consult the outboard engine Service Manual under the Fuel/Oil Ratios in Chapter 1.

B. Topic: Outboard lower units in freezing weather

Discussion: Water that leaks into the gearcase or is left in the cooling system can freeze when the engine is removed from the water. This can cause serious damage by cracking the gearcase. Prior to deployment/redeployment, remove all water from the cooling system. When removing the engine from the water, keep it in a normal (vertical) position until the system is completely drained. Raising and lowering the engines several times will assist in this draining process.

Check the gearcase lubricant before operating in freezing temperatures. The gearcase lubricant will appear milky in color if there is a leakage problem. If leakage is found, gearcase seals will need to be replaced.

To avoid engine damage due to freezing, keep the gearcase submerged in the water at all times until the craft is removed from the water.

Recommendation: Consult the outboard engine Service Manual under the Special Operating Conditions section in Chapter 1.

C. Topic: Boat crews

Discussion: Extreme cold weather places endurance limitations on the amount of time a coxswain can effectively operate his craft. Driving an open-decked craft in open water with high winds and sea spray in Norway (or anywhere) can lead to hypothermic conditions. The coxswains, crew, and embarked passengers' minimal comfort level is limited by the ability of their cold weather clothing to keep them warm. This will be discussed at length under the Equipment Topic and Discussion Items.

Recommendation: Have multiple boat crews available for cold weather operations. Two hours is a good rule of thumb for boat crews in an open craft such as an RRC or a CRRC

5. Combat Rubber Raiding Craft (CRRC)

A. Topic: Stowage of the CRRC in extreme cold weather conditions

Discussion: The CRRCs and the Small Craft Propulsion System (SCPS) can be stored in the water in extreme cold weather conditions if proper precautions are taken. The situations below occurred in Seward, AK. The Marines of Company E, 4th Reconnaissance Battalion, 4th MarDiv, Elmendorf AFB, AK, provided most of the cures.

Snow in the CRRCs while stationary. During a 2-day period the CRRCs received 72 inches of snow. A heavy-duty plastic snow shovel was used to shovel off the pier, gunwales, and deck of the craft. A plastic dustpan and heavy bristle brush were used to remove the remaining snow from the craft. Plastic was chosen over metal to reduce the possibility of puncturing the gunwales.

Snow on the CRRCs while underway. During the 2-week DT/OT in Alaska, three Marines fell out of their craft due to a combination of events. The most common was that sea spray froze to the gunwales of their craft and also to their dry suits. This combined with Sea State 2/3 conditions caused the Marines to skid off the gunwales into the water. A recommendation has been made to Zodiac of North America to make a textured coating on the top of the gunwale tubes of the F-470 and SW variants. This would possibly assist in allowing the water to drain off the gunwales and provide additional traction to the Marines' dry suits.

Snow and ice on the SCPS. Initially the SCPS were stored, after daily use, with their tiller handles in the down or horizontal position, which caused several unforeseen problems. First, the snow and ice froze the throttle grips in place. This was overcome by warming them up by hand and slow twisting the grips. Second, the détente for the “kill switch” safety lanyard was frozen over. This was overcome initially by chipping away the ice until the “kill switch” key would fit into its détente. However, we did not realize that the movement of this safety switch was also frozen. This did not become apparent until a coxswain fell out of his CRRC and the engine did not shut down when his lanyard pulled off the “kill switch.” He and his assistant coxswain later determined that the switch mechanism had frozen in place. This may also have been aggravated by sea spray freezing into the switch mechanism while underway. This situation was overcome by securing the tiller handle in the up or vertical positions whenever the craft and engines were not in use. Another solution is to cover the kill switch area on the tiller arm with a Velcro piece of neoprene. This was not tried because we did not experience this situation again.

Recommendation: Procure several plastic snow shovels and dust pans for use in snowy climates. Stow the SCPS tiller arms in the up or vertical position when not in use. Cover the “kill switch” mechanism on the tiller arm while underway in extreme cold weather conditions to help prevent freezing of the throttle grip and the “kill switch.”

B. **Topic:** Zodiac bellows pump hose

Discussion: The yellow Zodiac bellows pump hose used to manually inflate the CRRCs breaks in freezing weather. While filling the gunwales of the CRRCs in freezing weather, do not leave the yellow bellows pump hose exposed to cold weather any longer than necessary. The hose **will** become brittle and break. This situation has been reported to Zodiac of North America.

Recommendation: Do not store or leave the yellow bellows pump hoses out in the cold any longer than needed to inflate a CRRC. The Marines from Alaska keep their hoses in a warm vehicle, under a running vehicle exhaust pipe or inside their clothing next to their body to keep the hose from becoming brittle and breaking.

C. **Topic:** Starboard side aft gunwale deflation

Discussion: While conducting the DT/OT in several locations and climatic conditions, it was reported that the gunwales deflated on the starboard side aft—usually where the coxswain sits. A Marine in Alaska discovered and reported the cause of this situation. He noticed that the paddle bag had a tendency to swing in a pendulum motion while under way, and the paddles hit the gunwales' interconnecting valve on the starboard side just forward of where a coxswain would sit. This striking of the exposed interconnecting valve would slowly open the valve and cause the starboard side aft gunwale to deflate. The gunwales were noticeably underinflated after a 2-hour period. This situation tends to get worse in heavier Sea States and has been reported to Zodiac of North America.

Recommendation: Cover the interconnecting valves with the protective covering provided with the craft. Check the valve periodically and retighten if necessary.

D. **Topic:** Use of fuel additives in cold weather operations

Discussion: Initially it took 15 to 20 pulls on the engine starting rope to start the SCPS in Alaska. This occurred with air temperatures between 18 to 33 degrees Fahrenheit and saltwater temperatures between 29 to 33 degrees Fahrenheit. Discussions with local rental and repair personnel led us to try fuel additives to decrease SCPS starting time.

We first tried a product called Heet Plus, obtained from a local NAPA automotive store. This reduced our start time to one or two pulls on the engine starting rope. We were also informed of another fuel additive called Sea Foam. The local Alaskans touted Sea Foam over Heet Plus and other additives. We purchased a can of Sea Foam and did not have time to use it. However, we did give this to the OMC Technical Engineers at Waukegan, IL. The OMC engineers were already familiar with Sea Foam and stated that this is a much better product to use in extreme cold weather environments than their own OMC 2+4 Fuel Conditioner.

Recommendation: OMC recommends Sea Foam for all of their 2-cycle outboard engines because its ether additives help thin the fuel oil mixture. Use of Sea Foam will not void an OMC warranty. OMC states not to exceed the Sea Foam mixture instructions provided on the can. Sea Foam is available from P.O. Box 5178, Hopkins, MN 55343-1178; Phone (612) 938-4811 or Fax (612) 938-5841.

E. **Topic:** Use of the CRRC and SCPS in icy conditions

Discussion: While in Alaska, the CRRCs and SCPS were started and operated in slushy and icy conditions. Several mornings the CRRCs had to break through several hundred yards of up to 3 inches of solid ice in order to get out of the harbor into the bay.

Recommendation: None. For information only.

F. **Topic:** Pot metal and plastic fatigue

Discussion: Expect pot metal and plastic components to break or fail under extreme cold weather conditions. Due to metal fatigue, the pot metal engine clamp handles on the SCPS mounting brackets broke on an alarmingly regular basis under normal torque conditions. The pot metal clamp handles will be replaced on the production model SCPS with a stainless steel through bolt system similar to that used on the 35-hp I-MARS transom stiffening kit. The plastic fuel manifolds, tee nipples, and throttle linkage connections were prone to brittleness in cold weather. These plastic items will be replaced with metal components on the production model SCPS.

Recommendation: None. For information only.

G. **Topic:** Maintenance facilities

Discussion: A local fish cannery was used in Alaska to assemble the CRRCs and served as an indoor maintenance facility. This proved to be an invaluable asset for all maintenance performed. Working pierside on an open craft is difficult at best. Dropped tools may sink into 20 feet of water.

Upon completing a mission operating in salt, polluted, or brackish water, a fresh water internal flushing is recommended to prevent deposits from clogging the cooling passages of an outboard engine. When the flushing is completed, the cooling system should be allowed to drain completely by placing the engine in a normal (vertical) position. This procedure is best completed in a heated indoor facility. Doing a fresh water flushing outside could create an ice hazard.

Recommendation: The use of a heated indoor maintenance facility during cold weather operations is imperative. The number and types of craft that are stored and maintained in it should dictate the size of the facility. Electrical requirements should be taken into consideration.

6. **Riverine Assault Craft (RAC)**

A. **Topic:** Cold weather preparation of the RAC

Discussion: SCC consulted with MARCORSYSCOM, Marine Corps Engineer School, and Cummins concerning the use of the RACs in freezing water. Based on these recommendations, block heaters were purchased and installed. Annual PMs were conducted on the RACs and the bilges were drained prior to embarkation to Norway. While staged at Moorehead City, NC, and prior to SCC retrieving the craft in Norway, they were exposed to rain, freezing temperatures and uncovered outdoor storage. Many of the maintenance problems that the RACs sustained in Norway were a direct result of inadequate storage facilities.

Recommendation: RACs should be stored in a covered area at the point of embarkation and debarkation. They should remain in covered and heated storage facilities in cold weather until they are turned over to the owning unit.

B. Topic: Maintenance Facilities

Discussion: The Norwegian rubber halls are outstanding structures for use in cold weather environments. Use of these halls as maintenance facilities proved to be critical for preventive and corrective maintenance. Working on an open craft in cold weather conditions is difficult at best. Having an enclosed and heated facility speeds up repairs.

Recommendation: The use of a heated indoor maintenance facility during cold weather operations is imperative. The number and types of craft stored and maintained in it should dictate the size of the facility. The door for a facility housing a RAC should be 20 feet wide by 10 feet tall. This facility should have enough electrical outlets to allow the RACs' block heaters to be plugged in and to support mobile lighting for maintenance actions.

C. Topic: SCC advance party

Discussion: Maintenance difficulties associated with operating small craft (RACs & RRCs) in extreme cold weather were anticipated. Numerous preventive maintenance measures were taken prior to embarkation for BG-99. However, such measures cannot be expected to prevent all maintenance situations that extreme cold weather will present. The RAC and RRC were not designed to operate in this type of harsh environment. When craft are placed in cold water for the first time, adjustments will have to be made to them in order for them to run properly.

Recommendation: A detachment of mechanics and coxswains should arrive with the craft at the port of debarkation in order to receive them and ensure continuous operational availability.

D. Topic: Cooling system

Discussion: Each craft was inspected by the Marines upon arrival at Bangsund, Norway. Even though the raw water strainer baskets were drained prior to shipment, the Marines found frozen water in the strainer baskets and in the primary cooling system pipes. The water frozen in the strainer baskets cracked the strainer basket's plexiglass globe. Frozen water in the primary cooling lines blocked raw water flow such that the engine cooling system was not functioning. The Marine Corps mechanics were required to repair the cracked strainer basket globe and to place each RAC in the heated maintenance tent for up to two days prior to operations to thaw the frozen water in the raw water cooling lines.

Naval Surface Warfare Center (NSWC), Crane Division (CD), Detachment Fallbrook, Marine Corps Programs Department (MCPD) conducted a limited study of the water trapped in the cooling system, see Appendix summary. The study confirmed that it is extremely difficult to remove all of the water in the engine and in the cooling line pipes. The water trapped between the strainer basket and the engine will tend to drain back into the strainer basket, the low point in the path, during shipment. Similarly, the primary cooling lines trap water in their low points that can not be drained unless the bow of the craft is raised to an angle greater than 45 degrees.

MCPD concluded that without changes to the cooling systems, the problems experienced by Marine Corps mechanics can not be avoided.

Recommendation: Devise a revision to the raw water strainer basket and the primary cooling lines to permit draining of all of the entrapped water.

E. **Topic:** Engine batteries

Discussion: During the pre-operational check, the craft's engines failed to start because the batteries had very low charge to start the engine. As documented in the RAC TM, 09557A-14/1A, Riverine Assault Craft System Operation and Maintenance, the batteries will drain during storage. Paragraph 6-8 of the TM states, "The maximum length of time these batteries should be allowed to sit without charging is 6 months. However, to properly maintain the batteries, and ensure optimum operational life, they should be charged every month."

Shipment of the RACs from Camp Lejeune to Bangsund, Norway, took approximately eight weeks. Batteries normally produce less charge in cold weather environments and the batteries did not receive the recommended monthly charge. The solution is to replace all engine batteries with new ones prior to extended shipments to cold weather environments.

Recommendation: Install new engine batteries prior to shipments over one month, especially to cold weather environments.

F. **Topic:** Slave cables for jump starting the RAC diesel engines

Discussion: The slave cable for jump starting the RAC is 20 feet long and designed to reach from one craft to another. However, the crafts were launched one at a time and the first RAC's batteries were low, there was no adjacent RAC to jump start with the slave cable. The RAC had to be jump started by the launch vehicle. The 20-foot slave cable required the vehicle and the RAC to be maneuvered in position that the slave cable could reach.

This problem can not be resolved with the current RAC supply list. However, it should be possible to provide an electrical coupler to connect two slave cables together to make a 40-foot long slave cable. Marine Corps Logistics Base, Albany should be tasked to research and provide coupler information to the users.

Recommendation: Task Marine Corps Logistics Base, Albany to research and provide an electrical coupler to connect two slave cables for the RAC. If no electrical coupler is currently available in the system, a unique coupler may have to be designed and added to the RAC supply list.

G. **Topic:** Engine Starters

Discussion: One of the engine starters failed prior to use and was replaced with a new Prestolite starter. Unfortunately, the new starter provided by Prestolite has certain minor differences from the Prestolite starter that was used during the FY96 system improvement ECP, reference (g). The differences between the two starters are not documented and had lead to installation problems. This could only worsen because Marine mechanics rotate through the RAC system so quickly.

Recommendation: MCPD should work with Prestolite to determine if they have a final configuration for their starter, and update the starter information in the TM. Prestolites changes to the engine starter must be documented to make replacement easier.

H. **Topic:** Engine Failures

Discussion: After fixing the problems with the batteries and the starters, two engines failed to operate. MCPD representatives left Norway prior to determining the cause of the two engines failure. Following incorporation of RAC cooling system and engine monitoring ECPs, the engine problems caused by failures in the raw water strainer baskets, engine sensors and monitoring gauges appeared to decrease. Based upon this Norway experience and other failure information being reported by the users, the engine failure rates may again be on the rise. Collection of engine failure rate documentation and cause of failure data is necessary to isolate potential new RAC engine problems.

Recommendation: Engine failure rates and causes need to be investigated and documented to determine if new problems are occurring.

7. **Cold Weather Equipment**

A. **Topic:** Dry suits

Discussion: The dry suits proved to be very effective cold weather equipment except for the feet. The foot area was very constricted and would not allow for the use of layered socks. Marines said after an hour and a half their feet started to get cold. By the end of two hours their feet were very cold and at three hours their feet were starting to hurt.

Three Marines fell overboard from the CRRCs into 29 to 33 degree Fahrenheit water while wearing their dry suits. No one suffered any problems due to hypothermia or exposure. One of these Marines did get wet because he failed to properly seal his neck gasket. The equipment works well if worn properly.

Recommendation: The MARCORSYSCOM Dry Suit Project Officer participated in the SCPS DT/OT and is personally aware of this situation. He is looking at doing an Engineering Change Proposal on the Dry Suit foot booties.

B. Topic: Gloves

Discussion: Contact gloves made of polypropylene or thermax are necessary at a minimum for conducting maintenance in extreme cold weather conditions in contact with metal objects. These contact gloves covered with a Gore-Tex, thinsulate-insulated outer shell provide minimum comfort and protection for up to 8 hours while wet.

Recommendation: MARCORSYSCOM should pursue a more effective glove system for use on open small craft in extreme cold weather conditions.

C. Topic: Head gear

Discussion: During the DT/OT evening debriefs, Marines often commented about their head and face being cold. This was due to operating in Sea State 3 conditions, temperatures in the low teens, winds up to 20 knots, snow, ice, and freezing rain. While discussing this situation pierside, a Boatswains Mate from the Coast Guard Cutter Mustang told of headgear provided to them by the Coast Guard. It is a 1000 polar fleece, wind block lined, tube style hat that is black in color. We later found out that the U.S. Army at Ft. Richardson and the U.S. Air Force at Elmendorf AFB issue these "Head Sokz" to their troops. They are manufactured by Gotta Go, Inc., 725 Industry Drive, Tukwila, WA 98168-3407, Phone (800) 946-8824, Fax (206) 575-1924, Web Page: <http://www.gotta-go.com>. Cost is \$25 each. Ask for the military black on black version without the company name logo. Several of us purchased a "Head Sokz" for personal use and are very pleased with their performance. They are easily adjusted, warm, and waterproof.

Recommendation: None. For Information only. Examples of the Head Sokz have been provided to MARCORSYSCOM (CLSE) for cold weather clothing consideration.

D. Topic: Fuel bag spills

Discussion: During two separate occasions in Alaska, we experienced fuel spills at a gasoline station due to ruptured fuel bag seams or a broken fuel fitting. Both situations involved 6-gallon fuel bags. During the clean-up process, several local residents informed us of a product called "Sorbies." These are pads that absorb oils, fuel, and any other petroleum-based product, but are hydrophobic (repel water). Therefore, these oil absorbent pads effectively soak up oil and fuel spills on both land and water.

This product can be purchased through McMASTER-CARR. The PN for the 16-inch by 20-inch oil absorbent pads is 7516T47. They come in packages of 50 with a unit price of \$0.35 each. These are ideal for the 6-gallon fuel bags. The PN for the 33-inch by 39-inch oil absorbent pads is 7516T48. They come in packages of 25 with a unit price of \$2.31 each. These are ideal for the 18-gallon fuel bags.

Sorbies are inexpensive and effective ways of containing a fuel spill before it gets out of hand. They are highly recommended for refueling and defueling operations and should be considered for deployment mount out blocks.